

A circular window view of a Martian landscape. The scene shows a vast, reddish-orange desert with scattered rocks and a clear sky. In the foreground, two large, dark solar panels are partially visible, suggesting the presence of a rover. The window frame is dark and metallic.

HEO Overview and Accomplishments Update

Greg Williams | HEOMD | July 24, 2017

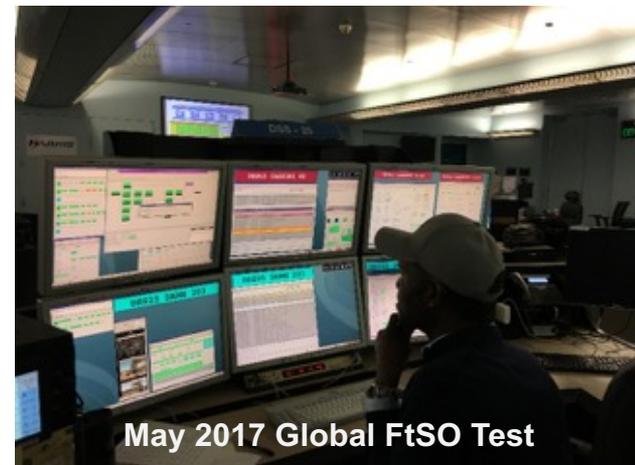


Space Communications and Navigation

Network Operations Accomplishments



- Maintained Network proficiencies (May 2017):
DSN @ 98.9% **NEN @ 99.5%** **SN @ 99.96%**
- DSN Follow-the-Sun Operations (FtSO) Delivery and Soak installation occurred on June 26
- Sardinia Deep Space Antenna (SDSA) microwave feed installation completed May 2017
- The NEN Kennedy Uplink Station (KUS) antenna system successfully performed the first auto-tracking of a rocket on the May 1 SpaceX launch, and supported again on May 15
- New antenna in Alaska installed; electronics now in work
- The AS2 Site Acceptance Test successfully completed at ASF on April 6
 - Shadowed tracked AQUA, AURA, SMAP, AIM, GRACE 1/2, OCO-2, QUICKSCAT, SciSat, and JASON2
- SN upgrades to support EM-1 completed successful SRR, SDR, and ConOps reviews
- Now supporting ISS at 300 Mbps via Guam (Space Network)
- Perimeter Surveillance and Intrusion Detection System (PS&IDS) ORR successfully completed on June 27



May 2017 Global FtSO Test



PDL Electronics Installation



Space Communications and Navigation

Network Development Accomplishments



- Tracking and Data Relay Satellite – M
 - Post storage testing complete (2/16/17)
 - Propulsion System Delta FIST testing complete (2/18/17)
 - Manual Antenna deployments and Gimbal motion test complete (3/7/17)
 - Payload Delta FIST testing complete (3/28/17)
 - Solar Wings installation and test complete (6/9/17)
 - Mass Properties test complete (6/13/17)
 - TDRS-M arrived at KSC and undergoing final testing (6/23/17)
 - All TDRS-M spacecraft testing, launch vehicle operations, and launch site planning is on track to support August 3 launch

- Deep Space Network Aperture Enhancement Project (DAEP)
 - DSS-53 and DSS-56 in Madrid, Spain
 - Received pedestal proposals
 - Received antenna proposals
 - Pedestal subcontract awarded
 - Antenna subcontract awarded
 - CoSpAI panels/mirrors/subreflector contract awarded
 - Completed excavation work for DSS-53/56
 - Rebar placement is underway on DSS-56





Space Communications and Navigation

Accomplishments



- **Technology development and demonstration**

- Deep Space Atomic Clock
 - Official launch remains December 2017, planning is currently for launch in end of April 2018 with a significant risk of delay.
- Optical communications for near Earth relays
 - Laser Communications Relay Demonstration (LCRD) payload nearing completion for delivery in 2018
- Deep Space Optical Communication
 - Psyche asteroid mission carrying Space Technology Mission Directorate-provided deep space optical terminal planned for 2022 launch (formerly 2023) and arrival at Psyche in 2026 (formerly 2030).
- SCaN-provided optical ground stations under development
 - Optical communication flight terminal demo approved for launch on Orion EM-2

- **Spectrum Management**

- Continuing providing regulatory and technical leadership to World Radiocommunications Conference (WRC-19) preparatory activities
- Continuing to provide spectrum support to Commercial Crew Program

- **Policy and Strategic Communications**

- Outreached to 135k people throughout 11 events
- Goldstone Apple Valley Radio Telescope (GAVRT) provided teacher training in Los Angeles, CA, Lanham, MD, and Chantilly, VA
- GPS Space Service Volume (SSV) Development: NASA-led interagency update GPS III specs to reflect existing capabilities to support space users
- Led the NASA delegation to International Committee on Global Navigation Satellite System (ICG) Intersession Meeting in Vienna, Austria on June 6-9 and provided an update on recent NASA GNSS activities, including assessment of GNSS signal coverage for lunar missions.
- Renewed charter for the Position, Navigation and Timing (PNT) Advisory Board
 - NASA-sponsored 19th PNTAB on June 28-29; Focus on protecting GPS users from harmful interference by proposed terrestrial LTE network.

- **Data Standards**

- CCSDS has agreed on an approach and is working towards the development of four optical communications standards (High Data Rate, Deep Space, Low Complexity and Weather Prediction data exchange)
- Six new standards are in development or review.

Human Spaceflight Capabilities Progress and Updates



- The Potomac Institute was selected to conduct an independent cost analysis for the implementation monitoring, diagnosis and treatment of health issues associated with space flight for former astronauts. This need for study was included in the “*To Research, Evaluate, Assess, and Treat Astronauts Act*” ([H.R. 6076](#))(TREAT). The kick-off meeting with Potomac Institute was held on 7 July and they have begun their study.
- RPT completed a hot fire test in the Plum Brook B-2... this is now referred to as the In-Space Propulsion test facility. This was the JSC Morpheus lander that has been flown at KSC. It is a 10K lb thrust engine and the first hot fire test in that facility in many years
- At MAF we have received supplemental funding (\$109M) to repair the facility from the Feb tornado.



Pres Trump signing the TREAT



Tornado damage to Michoud Assembly Facility



ISS Accomplishments



- **EVA**
 - 3/24 US EVA 40 (6:34 hr, EXT-1 MDM install, SPDM LEE Lube)
 - 3/30 US EVA 41 (7:04 hr, EXT-2 MDM install, PMA 3 connect)
 - 5/12 US EVA 42 (4:13 hr, ExPCA install)
 - 5/23 US EVA 43 (2:46 hr, EXT-1 MDM R&R, Lab EWC Antenna)

• Visiting Vehicles

- 4/20 – 6/4 OA7 berthed mission
- 4/20 50 Soyuz docking
- 6/5 – 7/3 SpaceX 11 berthed mission
- 6/16 Progress docking

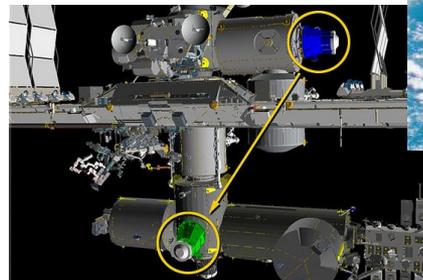


• Utilization/Tech Demo

- ROSA
- Rodent Research 4, 5
- SARCOLAB
- SAGE III
- MUSES
- NICER
- And many others



PMA3 Relocation



• Maintenance/Outfitting/Robotics

- RELL Surveys
- NH3 Vent
- MBSU R&R
- N1 Galley rack activation
- PMA3 relocate
- X2R15 transition



LAB EWC Antennas



ROSA



MUSES



NICER





CCP – SpaceX Accomplishments



- **Certification Products**

- Numerous Verification Events approved and Phase II Hazard Reports are progressing
- Received updated deliveries of Configuration Management, Risk Management, and Safety and Reliability Plans

- **Demonstration & Test**

- Buck Mock-up returned from vendor after interior panel installation in July
- 2 Hardware-in-the-Loop (HITL) tables assembled in support of software testing with flight computers and vehicle Remote Input Output units
- Performed acceptance testing of Demo-1 components including heatshield
- Continued Validation Propulsion Module Build up for McGregor test
- First Demo-1 joint simulation was performed with MCC-H and MCC-X
- Lightning Protection System Installed at LC-39A, and crew access arm and white room installation planned for late fall



Mock-up of Crew Dragon Flight Deck



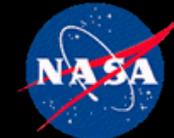
Merlin Engine Test



LC-39A Lightning Protection System



CCP – Boeing Accomplishments



- **Certification Products**

- Numerous Verification Closure Notices and Phase II Hazard Reports have been approved
- Received updated deliveries of Configuration Management, Risk Management, and Safety and Reliability Plans

- **Demonstration & Test**

- Additional arc-jet testing of Boeing Lightweight Ablator (BLA) shoulder completed
- Two Land Landing Qualification Tests completed
- Continued progress with Structural Test Article campaign
 - Proof Pressure Test complete
 - Service Module Fixed Base Structural Test complete
 - Ascent Cover and Landing/Recovery Systems Shock Tests in progress
 - Commercial Crew Transportation Services Modal testing



Structural Test Article (STA)



Wind Tunnel Testing



LC-41 Emergency Egress

GeneLab now hosts 116 data sets available world-wide



GLDS-119

Effect of microgravity on an animal-bacteria symbiosis

Organisms	Factors	Assay Types	Release Date	Description
Euprymna scolopes	Simulated Microgravity	transcription profiling	28-Apr-2017	Spaceflight imposes numerous adaptive challenges for terrestrial life. The reduction in gravity, or microgravity, represents a novel environment that can disrupt homeostasis of many physiological processes. Additionally, it is becoming incr...



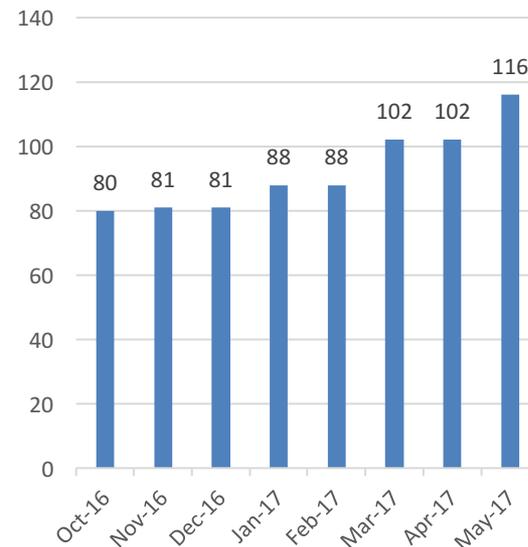
GLDS-118

Transient gene expression profile changes of confluent human fibroblast cells in spaceflight

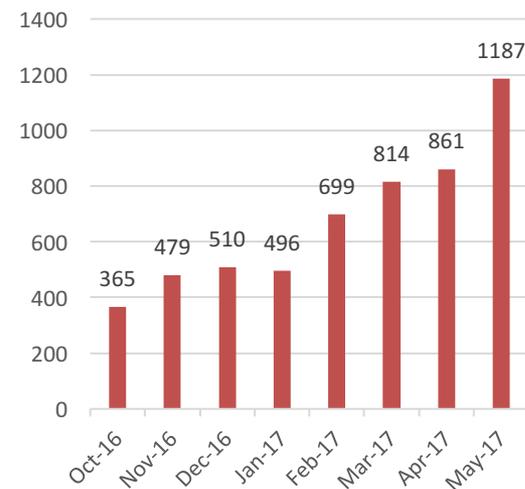
Organisms	Factors	Assay Types	Release Date	Description
Homo sapiens	microgravity timepoint	transcription profiling transcription profiling	28-Apr-2017	Microgravity or an altered gravity environment from the static 1g has been shown to influence global gene expression patterns and protein levels in cultured cells or animals, but it is unclear how these changes in gene and protein expressio...

- ◆ Data federation/integration with NIH/NCBI's GEO and EBI's PRIDE external databases. In work.
- ◆ Enhanced “Google-like” full-text search capabilities across multiple heterogeneous databases (GeneLab, GEO, PRIDE). In work.
- ◆ Collaboration with National Institute of Standards and Technology developed to enhance sample validation and verification approaches. In work.
- ◆ Release 1.0.17 (Legacy data and minor software update) – 4/28/17
- ◆ New PM and PS in place as of 5/15/17
- ◆ Release 2.0 planned for 9/29/17

Number of Data Sets



Number of Downloads

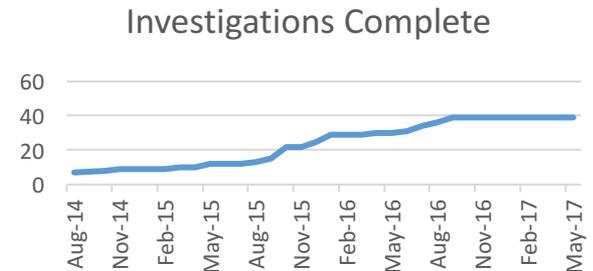
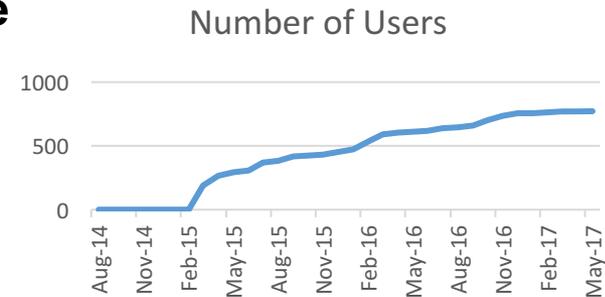


◆ **PSI contains 39 investigations available world-wide**

- Combustion Science – 8
- Complex Fluids – 12
- Fluid Physics – 6
- Fundamental Physics – 3
- Materials Science – 10

◆ **NRA selections on annual cadence, mapped to academic calendar**

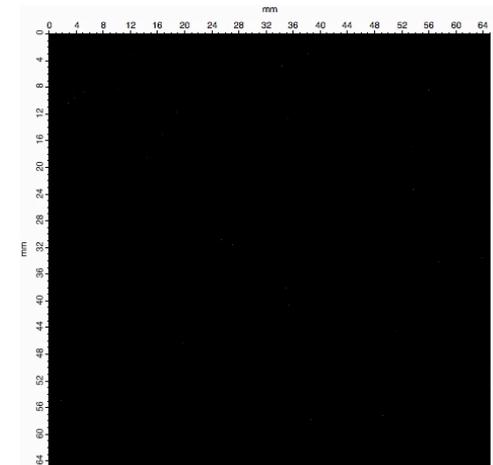
- Appendix A: Jun 2015 – Jan 2016; 2 Proposals Awarded
 - Combustion - 1
 - Fluid Physics - 1
- Appendix B: Jan – Mar 2016; 8 Proposals Awarded
 - Combustion Science – 2
 - Complex Fluids – 1
 - Fluid Physics – 2
 - Materials Science – 3
- Appendix C: Sep 2016 – Jun 2017; 6 Proposals to be awarded
 - Combustion Science - 2
 - Complex Fluids - 1
 - Fluid Physics - 2
 - Materials Science - 1



- ◆ **CFI is an outgrowth from the Flame Extinguishment Experiment (FLEX) using the Multi-user Droplet Combustion Apparatus (MDCA) in the Combustion Integrated Rack (CIR)**
 - After hot-flame extinction, the droplet can continue to burn with a cool flame; was discovered during FLEX
 - Previously hypothesized over 100 years ago, but never observed; widely thought to be impossible
 - Required the long-duration microgravity time available on the ISS
 - CFI utilizes specific fuels and atmospheres to study this cool flame droplet burning utilizing new and specialized diagnostics
- ◆ **The low-temperature flames responsible for cool-flame droplet burning are extremely important in real engines**
 - Related to octane and cetane number of fuel
 - Poorly understood because they are difficult to study
 - Preliminary flight data shows inadequacy of current kinetic models
- ◆ **Current Status: Completed ~15% of Full Success Test Matrix (Minimum Success = 20%)**
 - Robust set of test points (~70) in several atmospheres achieved; ~ 80% of first of five planned fuels is complete.
 - From Feb 21 (resolution of last anomaly to prevent ops) through Jun 9, CIR requested 48 ops days (avg 3/wk); ISS able to provide only 35 (avg 2/wk), due to lack of crew time, docked ops or other constraints, e.g. video.
 - Schedule at risk to complete full and/or substantial success (5 and/or 3 of 5 fuels, respectively) prior to reconfiguration of CIR to ACME, planned for Sep 1.



Shane Kimbrough
working on the MDCA

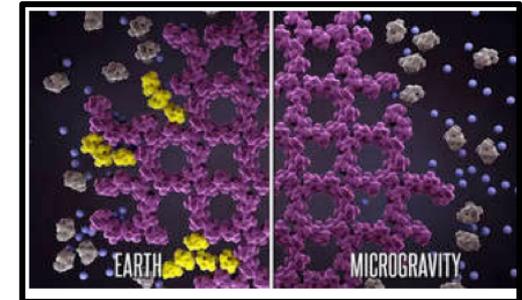


CFI Video on ISS – May 2017

- ◆ **Cool Flames Investigation (CFI) Continuing Operations in Combustion Integrated Rack (CIR)**
 - Ops began Dec 2017; Completed ~20% of desired test matrix (minimum success achieved); details on Project Highlight chart
- ◆ **Light Microscopy Module Biophysics 1 and 3 (LMM BIO-1, -3) Operations Completed**
 - LMM BIO, an LMM/Fluids Integrated Rack (FIR) investigation, is a CASIS collaboration (SLPSRA funded research and HW development w CASIS crew time), to study crystallizing proteins, which may be used to design new drugs and identify which types of crystals benefit from growth in microgravity. High quality, space-grown crystals could improve research for diseases, as well as microgravity-related problems such as radiation damage, bone loss and muscle atrophy.
- ◆ **Zero Boil Off Tank (ZBOT) launched on OA-7**
 - Exploration critical investigation to be run in Microgravity Science Glovebox (MSG), that will anchor fluid dynamics models that will enable efficient and effective cryogenic fluids storage and management in space propulsion systems



Final Mission Testing of CFI in CIR Ground Integration Unit



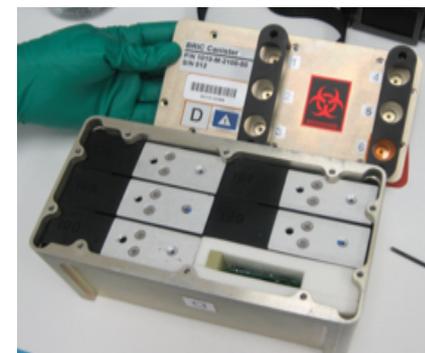
On ISS, crystals grow more perfectly, due to lack of sedimentation, which returns better research data.



PBRE Ground Unit

◆ Space Biology Payloads Returned on SpX-10

- **APEX-04 – PI: A. Paul:** This will be the first plant spaceflight experiment to directly investigate how the plant methylome contributes to space adaptation and help to increase understanding of how epigenetic methylation regulates plant adaptive responses when exposed to spaceflight environments.
- **RR-4 Space Biology Biospecimen Sharing Program**
- **Plant RNA Regulation** (in flight germination anomaly) - **PI: I. Perrera:** The goals of this research are to understand the molecular mechanisms by which plants sense and adapt to changes in their environment and to characterize the regulatory networks that mediate these responses through analysis of transcriptional and post transcriptional changes associated with early shoot and root development in microgravity.



◆ Space Biology Hardware Launched on OA-7

- Veggie SN001
- Advanced Plant Habitat SN002

◆ Space Biology Payloads Launched on SpX-11

- Fruit Fly Lab-02
- Rodent Research-5 Biospecimen Sharing Program
- **APEX-02-02 PI: T. Hammond** This study will conduct a high powered, genome wide analysis of yeast gene and radiation damage received on ISS. Given that yeast are eukaryotic organisms, the results will be applicable to organisms higher in the evolutionary chain.
- Descent of Veg-03A, 3B and 3C
- Microbial Tracking-2
- Seedling Growth 3





ESD Accomplishments – May 2017



Flame Trench Refurbishment project at LC39B - The final brick on the flame trench walls was laid on May 9, completing the installation of all 93,645 refractory bricks.



A construction worker installs the final brick on the north side of the flame trench at Launch Complex 39B at NASA's Kennedy Space Center in Florida.



EM1 crew module completed clean room operations in May 2017



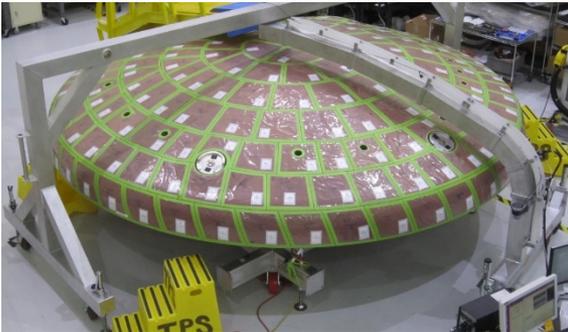
On May 15, the Core Stage Engine Section (ES) Structural Test Article (STA) arrived at the MSFC dock from Michoud Assembly Facility (MAF) on the NASA Barge, Pegasus. The ES STA was unloaded and transported via the Engine Section Transporter to the Load Test Annex Extension in Building 4619 on May 17 where it will undergo structural qualification testing. This is a significant milestone since this is the first of four STAs to be delivered to MSFC for testing.



ESD Accomplishments – June 2017



On June 15 the abort motor team successfully fired the Qualification Motor-1 (QM-1) motor at the Orbital-ATK facility in Promontory, Utah. This was a “hot” motor conditioned to ~100f and it burned for the full 5 seconds and generated the expected 480k lbf of thrust. QM-1 marks the beginning of the motor qualification program for the Launch Abort System.



In June 2017, the heat shield tile bonding was complete at the Operations and Checkout building at Kennedy Space Center.



On June 22, members of the Johnson team participated in a Vacuum Pressure Integrated Suit Test to verify enhancements to the suit will meet test and design standards for the Orion spacecraft. During this test, the suit is connected to life support systems and then air is removed from Johnson’s 11-foot thermal vacuum chamber to evaluate the performance of the suits in conditions similar to a spacecraft. The suit will contain all the necessary functions to support life and is being designed to enable spacewalks and sustain the crew in the unlikely event the spacecraft loses pressure.



ESD Accomplishments – June 2017



Technicians lifted the liquid hydrogen tank structural qualification test article into a cleaning cell at NASA's Michoud Assembly Facility in New Orleans where its insides will be thoroughly cleaned, coated and dried to certify the process for the following flight article. This represents a transition from activation/facility design to Process Development and Production operations with full-scale hardware.



As of June 16, The Mobile Launcher (ML) EIT successfully installed all eight (8) Vehicle Support Posts (VSPs), two Aft Skirt Electrical Umbilicals (ASEUs), and two Aft Skirt Purge Umbilicals (ASPU) on the main deck on the ML. The VSPs weigh ~ 11,000 lbs each and 4 VSPs hold and support each Solid Rocket Booster (SRB). They will be instrumented with strain gauges to measure loads during vehicle stacking, rollout and launch. The ASEUs weigh ~ 3600 lbs each and connect to the bottom outer edge of the SLS rocket's boosters and provide electrical power and data connections to the SLS rocket until lift off. The ASEUs also carry signals to the Launch Release System (LRS). The ASPUs connect to the SLS rocket at the bottom outer edge of each booster and provide a heated GN2 purge to remove potentially hazardous gases and maintain temperature range of components. The ASPUs will be connected during stacking operations in the Vehicle Assembly Building and will remain connected until T-0.



ESD Accomplishments – July 2017 (cont.)



Off the coast of Galveston, Texas, a NASA and Department of Defense team tested Orion exit procedures in a variety of scenarios July 10-14.



The Orion Stage Adapter (OSA) Structural Test Article (STA) was transported onboard the NASA Super Guppy aircraft to Denver, Colorado, on July 11 for use by the Orion Program. The effort was a collaboration between supporting MSFC organizations, the Redstone Airfield, and the Orion and Super Guppy organizations at JSC. The media event associated with the shipment included coverage on local television networks and the internet. In addition, the Super Guppy crew performed a fly-over of MSFC that provided an opportunity for the MSFC team to see this unique aircraft in flight. Use of the OSA STA provides a significant cost avoidance for Orion and a flight-like interface for planned modal, acoustic, and stiffness tests.



Human Exploration and Operations

Launch Services Program: FY 2017 Accomplishments

FY 2017 Accomplishments

- Provide end to end launch services management and support to over 40 missions in various stages of development
- Successfully launched Geostationary Operational Environmental Satellite (GOES)-R from CCAFS, Florida aboard an Atlas V on November 19, 2016
- Successfully launched Cyclone Global Navigation Satellite System (CYGNSS) from CCAFS, Florida aboard a Pegasus XL on December 15, 2016
- Successfully launch TDRS M in August 2017
- Successfully launch Joint Polar Satellite System (JPSS)-1 in October 2017
- Successfully completed certification effort for the Delta IV Heavy launch vehicle in support of the Parker Solar Probe mission in 2018
- Continue certification efforts of new commercial launch vehicles to launch high value civil payloads (e.g., Space X Falcon 9 “Full Thrust”, Orbital ATK Antares 230, ULA Vulcan, etc.)
- Continued providing advisory support, expertise, and knowledge to NASA programs and projects utilizing launch services not procured and managed by Launch Service Program
 - ISS CRS, CCP, James Webb Space Telescope, etc.
- Continue to conduct and manage the Venture Class Launch Service contracts for emerging small-class launch vehicles (e.g., Virgin Orbit’s “Launcher One” and Rocket Lab USA’s “Electron”)



FY17-FY18 Support Activity

Launch Services Program: FY 2017 Accomplishments



GOES-R
Nov 2016



CYGNSS
Dec 2016



OA-7
April 2017



CRS SPX 11
June 2017



TDRS-M
Aug 2017



JPSS-1
Oct 2017



ICON
Nov 2017



GRACE-FO
Dec 2017



GOES-S
Mar 2018



TESS
Mar 2018



InSight

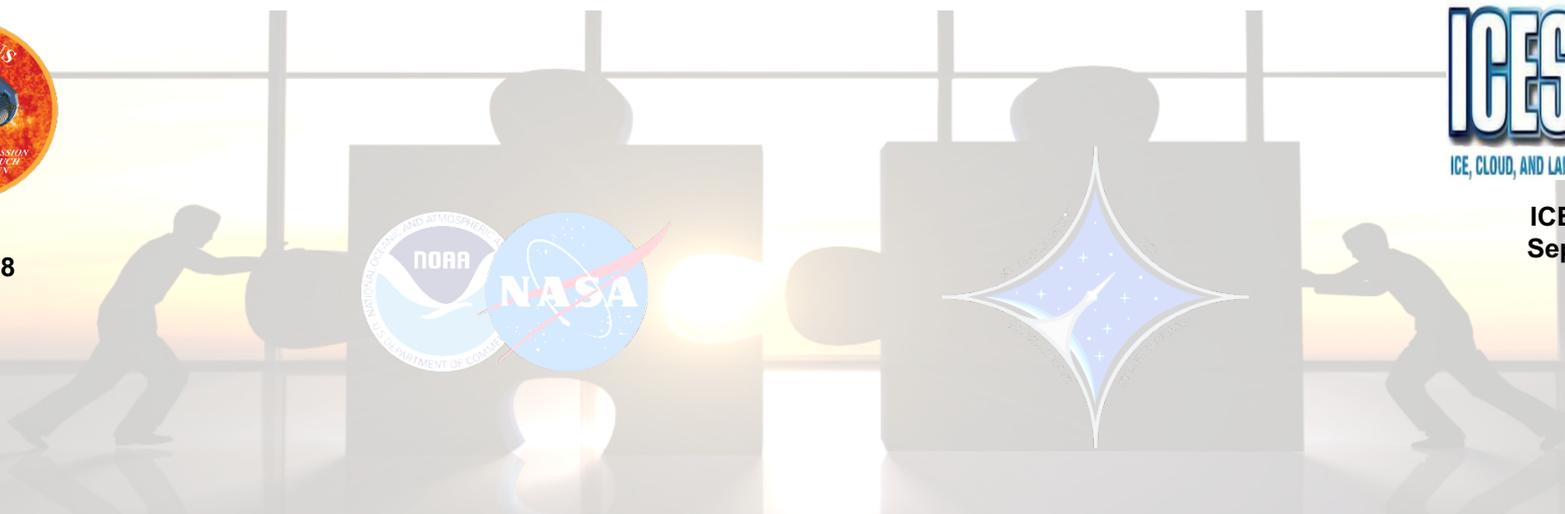
InSight
May 2018



PSP
July 2018



ICESat-2
Sep 2018



Advanced Exploration Systems

Spacecraft Fire Safety



- The Saffire-III fire safety experiment was launched on the OA-7 mission on April 18. Operations began on June 4 after Cygnus departed from ISS. 4,922 images and over 50 Gb of data and were downloaded.
- Saffire-III tested the same SIBAL cloth (75% cotton, 25% fiberglass) as Saffire-I, but at different flow conditions.
- Videos were captured of the fire propagating across a large material sample in the same direction as the air flow and in the opposite direction to the air flow. The initial results are consistent with Saffire-I, scaled to the higher flow velocity.
- Before re-entry, a Cabin Depress Assembly (CDA) test was conducted to evaluate how the pressure inside Cygnus could be reduced to a specific setpoint. The test results will inform the concept of operations for Saffire-IV-VI, which will be conducted at reduced pressure and elevated oxygen concentrations.
- Saffire-IV-VI will demonstrate combustion products monitoring and post-fire cleanup technologies. CDR is planned for late July.

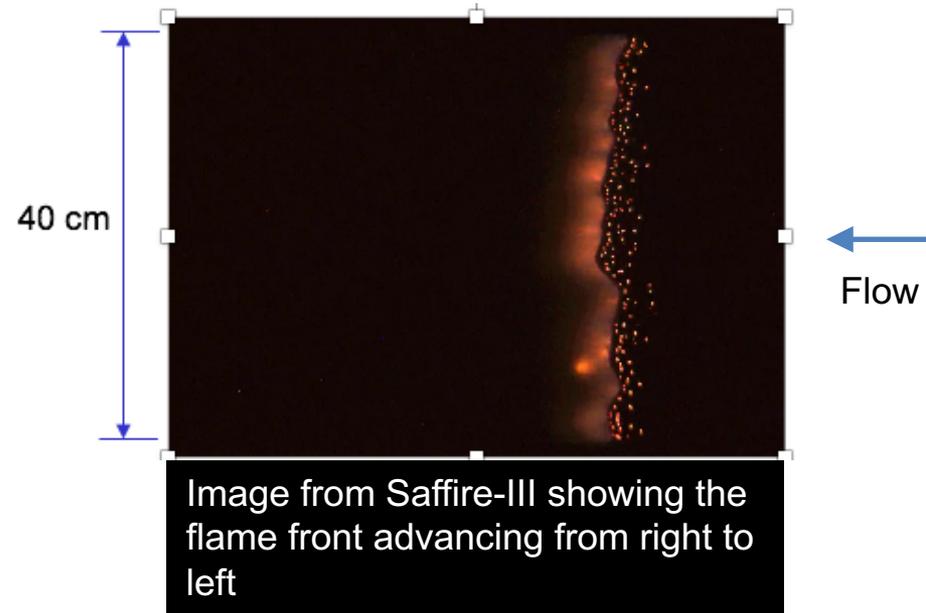


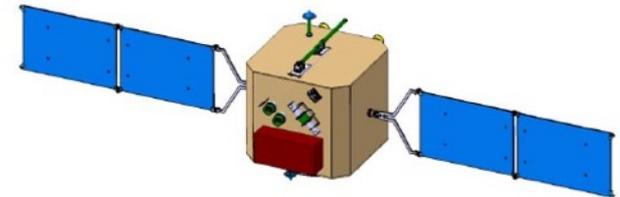
Image from Saffire-III showing the flame front advancing from right to left

Advanced Exploration Systems

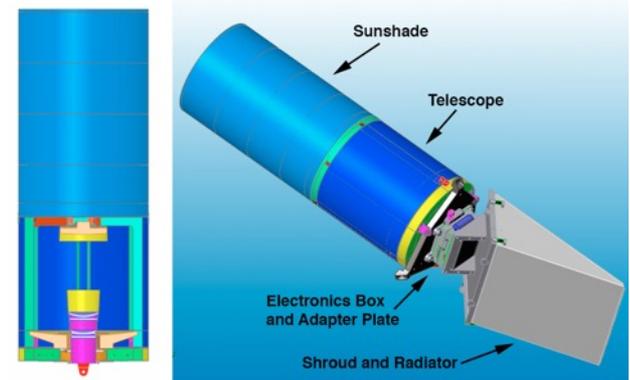
ShadowCam on KPLO



- Issued Announcement of Opportunity in September 2016 for NASA contributed instruments on Korea Pathfinder Lunar Orbiter (KPLO).
- Signed agreement in December 2016 with Korea Aerospace Research Institute (KARI) for hosting NASA instruments
 - KARI provides 15 kg payload mass in return for Deep Space Network support and assistance with lunar mission design and navigation
- Selected “ShadowCam” from Arizona State University and Malin Space Science Systems on April 28 to image the Moon’s Permanently Shadowed Regions (PSR).
- With over 800 times the sensitivity of the LRO Narrow Angle Camera, ShadowCam will map the long hidden PSR topography and provide science data to address lunar Strategic Knowledge Gaps, lunar Decadal questions, and further our understanding of lunar volatiles.



KPLO will carry five instruments to lunar orbit (four from South Korea and one from NASA)



ShadowCam

Advanced Exploration Systems

Lander Technology



- Two open-loop flight tests of the Cooperative Blending of Autonomous Landing Technologies (COBALT) payload were completed in April on the MSS Xodiac lander.
- COBALT consists of the Navigation Doppler Lidar (NDL) developed by Langley Research Center and the Lander Vision System developed by the Jet Propulsion Laboratory. During these tests, it was discovered that the on-board processor was overloaded.
- It was decided to defer the closed-loop flight tests planned for this summer. The project is planning to procure long-lead components for the NDL instead.



**COBALT is a partnership between
HEOMD and STMD**

In-Space Manufacturing

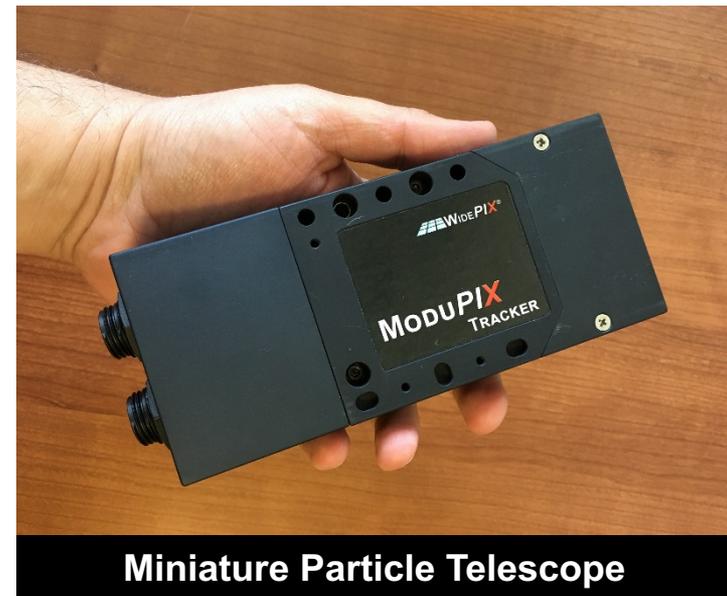
- Released a NextSTEP BAA for a multi-material Fab Lab on May 3. The Fab Lab will provide end-to-end manufacturing capabilities on ISS. Proposals are due on August 2, and require at least 20% cost sharing (10% for small business) by the commercial partners.
- Completed CDR for Refabricator technology demonstration on ISS. Refabricator will recycle plastic parts to produce feedstock for an integrated 3D printer.
- The Additive Manufacturing Facility on ISS was used to print radiation shielding enclosures for BEAM sensors. The crew installed enclosures of various thicknesses over the sensors to determine the effects of the inflatable module's structure on internal radiation levels.



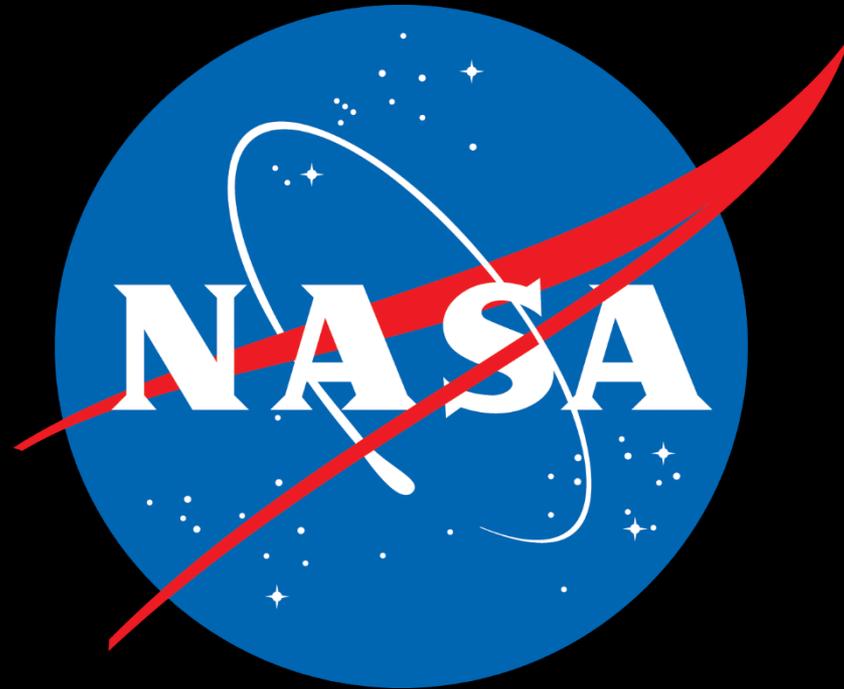
ISS crew 3D-printed & installed BEAM radiation sensor shields

Radiation Sensors

- A Miniature Particle Telescope (MPT) consisting of two stacked radiation detectors was launched on SpaceX-11 mission. The MPT will be used to determine the trajectories of incident ions in addition to their energies.



Miniature Particle Telescope



Questions?